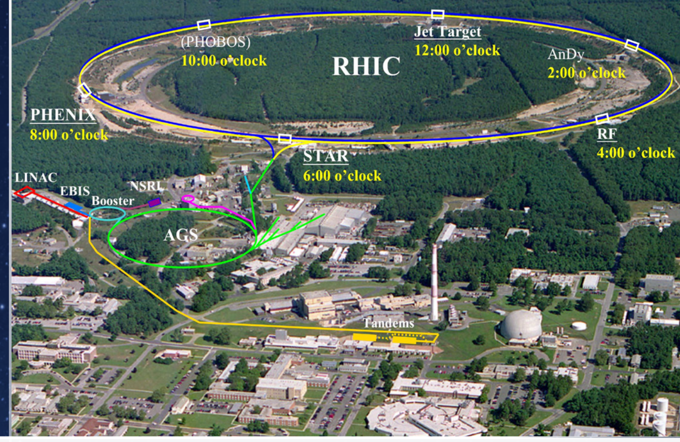
NASA
SPACE RADIATION LABORATORY



UNIQUE FACILITY FOR SPACE-RADIATION EFFECT STUDIES

APPLICATIONS

- Basic science of radiobiology in space
- Shielding studies
- Radiotherapy
- Space instrument effects
    - Aerospace validation
    - National defense
    - Homeland security
    - Rad hard electronics

NSRL@BNL

- NSRL is an extension of BNL's high-energy physics experiment facilities.
- BNL's Booster accelerator is the only facility in the US that can produce high energy heavy ions to closely mimic the space radiation environment.
- Although NSRL was established for radiobiology studies, its unique capability makes it well adapted for studies of space radiation effects on electronic devices and systems.

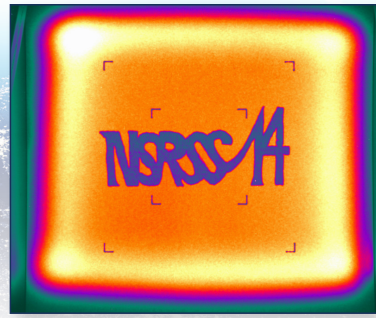
FACILITY HIGHLIGHTS

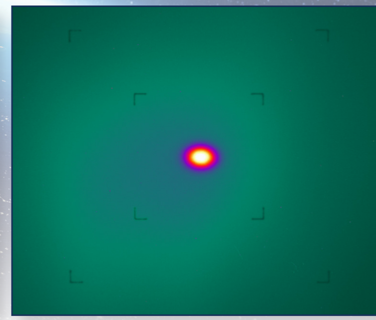
- Beams of all ions from protons to uranium
- High energy beams can penetrate electronics cases; no need to de-lid parts
- Flexible beam profile allowing simultaneous test of multiple devices or functional tests of complete systems
- Three beam cycles a year from mid spring to late fall
- Highly stable beam

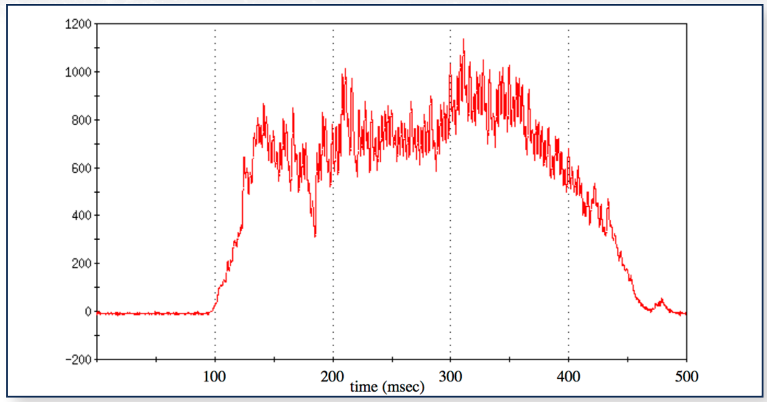
ACCELERATOR FACILITIES AT BNL

As the National Aeronautics and Space Administration (NASA) prepares for future missions to the Moon and Mars, many of the health risks of the space radiation environment are still uncertain. Before humans can travel for extended periods outside Earth's atmosphere, scientists must learn more about the risks posed by cosmic rays. To better understand these risks, NASA has teamed with the U.S. Department of Energy's (DOE) Office of Science to establish the NASA Space Radiation Laboratory (NSRL) at DOE's Brookhaven National Laboratory. There, scientists use beams of ions to simulate cosmic rays and assess the risks of space radiation to human space travelers and equipment.

Beam Features





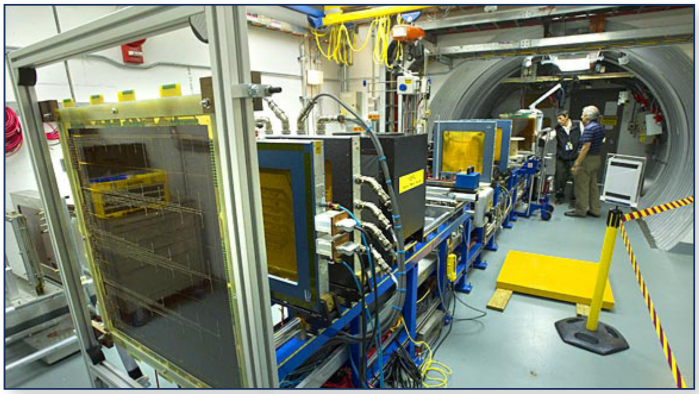


- Digital beam imager provides real-time information about beam intensity and shape.
- "Physics beam" is often a round Gaussian pencil beam, with FWHM of ~1 cm for a 1-GeV proton beam.
- Beam spots are somewhat larger for lower energy beams.
- Collimation down to ~1 mm is also possible.
- Typical beam profiles are the square 20×20-cm^2 profile and can be extended to 60×60-cm^2 profile.
- Beam uniformity is typically ±3% across the target field.
- Beam is delivered for 400 ms for every 4 seconds.

Ion Species and Energies previously used for Electronic Testing*

Ion Species	Max Energy (MeV/n)	LET in silicon at Max Energy (MeV/(mg/cm^2))	Peak LET in silicon (MeV/(mg/cm^2))	Range in silicon (millimeters)	Max Flux (ions/spill)
${}_{1}H^{1}$	2500	0.00171	0.530	5470	2.2x10^{11}
${}_{2}He^{3}$	1000	0.0069	1.45	1910	0.88x10^{10}
${}_{2}He^{4}$	1000	0.0072	1.5	1705	0.88x10^{10}
${}_{6}C^{12}$	1000	0.066	5.4	568	1.2x10^{10}
${}_{8}O^{16}$	1000	0.117	7.44	426	0.4x10^{10}
${}_{10}Ne^{20}$	1000	0.183	9.77	341	1.2x10^{10}
${}_{14}Si^{28}$	1000	0.358	14.5	243	0.3x10^{10}
${}_{17}Cl^{35}$	1000	0.528	18.1	206	0.2x10^{10}
${}_{18}Ar^{40}$	350	0.857	19.27	43.3	0.02x10^{10}
${}_{22}Ti^{48}$	1000	0.884	24.0	169	0.08x10^{10}
${}_{26}Fe^{56}$	1000	1.235	28.6	141	0.2x10^{10}
${}_{36}Kr^{84}$	383	3.28	40.1	26.5	2.0x10^{7}
${}_{54}Xe^{132}$	228	9.75	61.1	8.23	5.0x10^{7}
${}_{73}Ta^{181}$	342	14.8	83.3	10.6	3.0x10^{8}
${}_{79}Au^{197}$	165	24.7	90.2	3.70	1.0x10^{8}

**Other ions available upon request*



NSRL beamline

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U.S. DEPARTMENT OF ENERGY

BROOKHAVEN NATIONAL LABORATORY

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